



Raw Materials

Linseed oil is squeezed from seeds of the flax plant, widely grown in Canada, the United States and Argentina. Flax in the US is primarily grown in North Dakota in 3 to 6 year rotations with other crops, and requires no added nitrogen.

Rosin is harvested from pine trees, primarily in Portugal.

Sawdust is a by-product of lumber milling.

Cork is the bark of a type of oak tree that grows in the Mediterranean region, particularly in Portugal. The powdered cork used in linoleum is a by-product of manufacturing bottle corks, gaskets and cork flooring.

The fiber backing on most linoleum is a burlap or hessian made from **jute**, a plant that is grown in northeastern India and Bangladesh.”

Powdered **limestone** is used as a filler.

Titanium dioxide is the primary pigment.

Very small amounts of **zinc-based drying agents** are used in the processing.

Surface topcoat of **acrylic** usually applied.

Manufacturing Process

History: Armstrong had a manufacturing plant in Lancaster, PA until 1975, when it closed because of higher demand for petroleum based flooring products (Vinyl). “Today, the U.S. is importing some \$20 million to \$25 million worth of linoleum annually from four factories in Europe. This is just 1% of the \$2.6 billion resilient flooring market in the United States.”

Armstrong recently purchased the world’s #2 linoleum manufacturer - DLW Aktiengesellschaft (Germany). (Wilson 1998)

Process:

In a large tank, the linseed oil, rosin and drying agent are mixed together. Oxygen is pumped through the mixture for about 24 hours, oxidizing and polymerizing the linseed oil to produce a jelly-like intermediary material called cement. In this process, cross-bonds form between the glycerides in the linseed oil, causing the hardening. The cement is left to mature for several weeks, and is then mixed with the powdered wood, cork, limestone, and pigments. This granular material is calendared (rolled into sheet form), during which time patterns are created, then the sheets are pressed onto the jute backing with heat. These long sheets are hung up in drying rooms maintained at 150° - 180° Fahrenheit to cure for another two to three weeks. The oxidation process occurs during curing and provides much of the heat

needed to maintain the high temperatures. The final stage is to apply an acrylic topcoating and package the linoleum for shipping . . .

VOCs are generated at several stages of this process: those produced during initial oxidation in the large tanks are typically captured and burned to very high efficiency (99.9% pollutant removal); the VOCs released in the large drying rooms, however, are typically released to the outdoors. These emissions amount to 4.6 grams of emissions per square meter of linoleum produced, according to a 1995 report by Asa Jonsson, Anne-Marie Tillman, and Torbjorn Swensson, "Life-Cycle Assessment of Flooring Materials," published by the Swedish Council for Building Research in Stockholm. Solvents, chiefly toluene, butanol and ethyl acetate are also released during manufacture, although where they come from is not clear. They may come primarily from the acrylic topcoating. (Wilson 1998, pp. 8-9)

Embodied energy: 7,500 Btu/lb = 5,000 Btu/square foot for 2.3 mm thick material.

This figure includes energy for shipping raw materials from the Americas and Asia, but not to ship the final product back to the U.S. (Wilson 1998, p. 9).

Manufacturing Locations

4 in Europe (Germany)

Recycled Content

Not currently available

Installation

The typical adhesive for installing linoleum is a water-based SBR (styrene butadiene rubber) adhesive with low VOC emissions. Most butadiene is produced by the cracking of petroleum. Various health hazards are associated with exposure to butadiene, including eye and nose irritation, headaches, dizziness, and vomiting. Linoleum installation utilizing heat-weldable seams requires hot melt glue of an unidentified thermal plastic. Linoleum has to be protected from moisture from the substrate both during and after installation. It should not be installed over uncured concrete or where moisture emissions from the subfloor exceed 3.5 pounds per 1,000 square feet in 24 hours. (Wilson 1998)

Durability

Linoleum is long-wearing. It may actually get stronger with age as the linseed oil oxidizes.

Should not be installed on concrete floors below grade or on grade, and is not recommended for bathrooms or other "wet" areas.

Maintenance

"The linoleum surface is more porous than vinyl floors, so it's important to protect it with a high-quality polish. This will prevent spills or dirt from penetrating and staining the surface and will add a low-level gloss. The floor should be cleaned regularly using a neutral detergent solution. Because linoleum is made of natural materials, use of harsh alkalis or high pH

products such as ammonia should be avoided. Occasionally, re-apply two thin coats of floor polish; to avoid polish buildup, don't over-apply to low-traffic areas, such as along the walls.

“Linoleum floors are known to "bloom." Bloom is the term given to the minor color adjustments linoleum flooring makes when exposed to light. It turns its true color. Because linoleum is made from natural raw materials, oxidation of the linseed oil in the floor may result in a yellowish cast when not exposed to light (under the range, rug or refrigerator, etc.). This visual discoloration is only temporary. Once exposed to light, the yellowing disappears and the linoleum will "bloom" again.” (Armstrong World Industries)

Indoor Air Quality

VOC – Volatile Organic Compounds (linoleum) produced mostly during manufacture. Some VOCs are emitted by adhesives during installation of linoleum.

Recyclability

The material is biodegradable and readily broken down, primarily into carbon dioxide and water vapor. If incinerated in a waste-to-energy plant, combustion is very complete, with the linseed oil contributing significant energy.

No material recovery of linoleum after use occurs at the present time. Linoleum loses its softness after the linseed oil has been oxidized, and it is not known whether this change in the properties of linoleum would affect its suitability for recovery.

Cost

\$3.50 to \$4.50 per square foot installed for standard commercial grade sheet linoleum. (Armstrong World Industries, May 2002.)

Suppliers

Armstrong World Industries, P.O. Box 3001, Lancaster, PA 17604, (717) 397-0611, www.armstrong.com

Forbo Industries, P.O. Box 667 Hazleton, PA 18201, Ph (800) 342-0604, Fax (717) 450-0258, www.forbo-industries.com

Linosom, Domco, Inc. USA, P.O. Box 354, Florence, AL 35631, (800) 558-2240, www.domco.com

References / Resources

* available in the Environmental Works Resource Library

Armstrong World Industries, www.armstrong.com

Wilson, Alex. "Linoleum: The All-Natural Flooring Alternative," *Environmental Building News*, Vol. 7: No. 9 (1998); pp. 1, 8 – 16.*